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METHOD AND APPARATUS FOR FILTERING EXHAUST PARTICULATES

BACKGROUND OF THE INVENTION

[0001] The present disclosure relates generally to an exhaust system, and particularly to a particulate filter for an exhaust system.

[0002] Automotive exhaust systems for diesel and other internal combustion engines typically include a filtration system that limits the mass of particulate matter emitted with the exhaust gases. In diesel engine systems, this matter typically includes carbonaceous matter (soot) and ash particles. Present filtering methods to trap the exhaust particulates focus on wall-flow filtration. Wall-flow filtration systems typically have a high filtration efficiency not only for exhaust particulates but also for ash particles. Catalytic or thermal arrangements within the exhaust system, which serve to effect regeneration of the filtration element, cannot remove ash particles, thereby increasing the accumulation of ash particles within the filtration body with time. In view of present particulate filter arrangements, it is desirable to have a more advanced particulate filter that can operate with effective filtration and with limited accumulation of ash particles over time.

SUMMARY OF THE INVENTION

[0003] In one embodiment, a particulate filter for an exhaust system configured to manage an exhaust flow includes a housing and a wall-flow filtration element contained within the housing. The wall-flow filtration element is configured to trap exhaust particulates and to pass ash particles.

[0004] In another embodiment, a particulate filter for an exhaust system configured to manage an exhaust flow includes a housing having a first end and a second end and a wall-flow filtration element arranged within the housing. The wall-flow filtration element includes a ceramic monolith structure having porous internal walls defining inlet and outlet channels, the inlet and outlet channels being separated

by the porous internal walls to permit exhaust flow through the pores between the inlet and outlet channels. The inlet channels have inlet ports at one end and first end-plugs at the opposite end and are configured to receive the exhaust flow at the inlet ports, the inlet ports being arranged at the first end of the housing. The outlet channels have outlet ports at one end and second end-plugs at the opposite end and are configured to discharge the exhaust flow at the outlet ports, the outlet ports being arranged at the second end of the housing. The first end-plugs have greater porosity than the second end-plugs.

[0005] In a further embodiment, a method for filtering particulates of an exhaust flow of an exhaust system is disclosed. The exhaust flow is received at one end of a particulate filter having a ceramic monolith structure with porous walls defining inlet channels and outlet channels, the inlet channels each having an inlet port at one end to receive the exhaust flow and a porous plug at the opposite end, the outlet channels each having an outlet port at one end to discharge the exhaust flow and an end plug at the opposite end. The exhaust flow is filtered at the ceramic monolith structure as the exhaust flow passes through the porous walls between the inlet and outlet channels, exhaust byproducts are trapped at the porous walls, the end plugs, and the porous plugs, and ash particles are passed through the porous plugs. The exhaust flow is discharged at the outlet ports.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Referring to the exemplary drawings wherein like elements are numbered alike in the accompanying Figures:

[0007] Fig. 1 depicts an exhaust system employing an embodiment of the invention;

[0008] Fig. 2 depicts an isometric view of a particulate filter in accordance with an embodiment of the invention; and

[0009] Fig. 3 depicts a cross section view of the particulate filter of Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

[0010] An embodiment of the invention provides a particulate filter for an exhaust system of an automotive diesel engine. While the embodiment described herein depicts an automotive diesel engine as an exemplary diesel powerplant using a particulate filter, it will be appreciated that the disclosed invention may also be applicable to other diesel powerplants that require the functionality of the particulate filter herein disclosed, such as a diesel powered generator for example. While the disclosed invention is well suited for filtering the combustion byproducts of a diesel engine, it may also be applicable for filtering combustion byproducts of a gasoline powered engine.

[0011] An exemplary exhaust system 100 for an automotive diesel engine (not shown) is depicted in Figure 1 having a manifold exhaust pipe 110 suitably connected at one end to an exhaust manifold (not shown) of the diesel engine (not shown) for receiving an exhaust flow depicted generally as numeral 150. Turbocharger 140 is suitably connected to intermediate manifold exhaust pipe 110 and intermediate exhaust pipe 120. Intermediate exhaust pipe 120 is suitably connected to a particulate filter 200 for trapping exhaust particulates present in the exhaust flow 150, which is suitably connected to an exhaust pipe 130. A tailpipe (not shown) for exhausting the conditioned exhaust flow to atmosphere is suitably connected to exhaust pipe 130. Exhaust system 100 manages the exhaust flow 150 by controlling how the exhaust flow 150 passes from exhaust manifolds (not shown) to manifold exhaust pipe 110, turbocharger 140, intermediate exhaust pipe 120, particulate filter 200, exhaust pipe 130, and then to atmosphere. Exhaust system 100 has a nominal flow area equal to or greater than the inside cross-sectional flow area of manifold exhaust pipe 110.

[0012] Each particulate filter 200 has a housing 210, which may be any form of construction and configuration suitable for the purpose, and a filter element 220 suitably contained within housing 210, best seen by now referring to Figure 2. In an embodiment, filter element 220 is a ceramic monolith structure. Filter element 220 is of the wall-flow filtration type, meaning that exhaust flow 150 passes from the inlet channels 230, through the porous internal walls 240, to the outlet channels 250.

Filtering of the exhaust flow 150 primarily occurs as exhaust flow 150 passes through the pores of internal walls 240, hence the term wall-flow filtration. Filter element 220 is configured to trap exhaust particulates and to pass, or leak, ash particles (accumulated ash particles are depicted generally at 330 in Figure 3).

[0013] Inlet channels 230 each have an inlet port 260 at one end 310 and a porous end-plug 270 at the opposite end 320. Outlet channels 250 each have an outlet port 280 at one end 320 and an end-plug 290 at the opposite end 310. Exhaust flow 150 enters filter element 220 at inlet ports 260, passes through porous internal walls 240, and is discharged from filter element 220 at outlet ports 280. In this manner, inlet channels 230 and outlet channels 250 are referred to as being in fluid communication with each other via internal walls 240. To facilitate the trapping of exhaust particulates and the leakage of ash particles at porous end-plugs 270 (the leakage of ash particles is depicted generally at arrows 340 in Figure 3), porous end-plugs 270 are fabricated with a pore size equal to or greater than about 30 micrometers, and are preferably on the order of about 30 micrometers to about 60 micrometers. Internal walls 240 of filter element 220 are fabricated with a pore size less than about 30 micrometers, thereby enabling the entrapment of exhaust particulates. End-plugs 290 may be solid or may have a porosity similar to that of internal walls 240. In this manner, the artisan will readily recognize that in general, porous end-plugs 270 have a greater porosity than end-plugs 290.

[0014] In an embodiment depicted in Figure 2, filter element 220 is a ceramic monolith structure having a plurality of porous internal walls 240 that define and separate the inlet and outlet channels 230, 250. Inlet and outlet channels 230, 250 are arranged parallel to the direction of exhaust flow 150, resulting in a sideways flow (depicted generally by arrows 300 in Figure 3) as exhaust flow 150 passes through internal walls 240. Housing 210 includes a first end 310 and a second end 320. Inlet ports 260 and end-plugs 290 are arranged at first end 310, and outlet ports 280 and porous end-plugs 270 are arranged at second end 320. In an embodiment, and as depicted illustratively in Figures 2 and 3, the overall surface area of porous end-plugs 270 is substantially less than the total surface area of internal walls 240, with an exemplary ratio being less than about 1:240.

[0015] The process by which particulate filter 200 filters particulates from exhaust flow 150 of exhaust system 100 will now be described with reference to Figures 2 and 3. Exhaust flow 150 is received at first end 310 of particulate filter 200, which has a ceramic monolith structure (depicted as 220) with porous walls (depicted as 240) defining inlet channels 230 and outlet channels 250. Inlet channels 230 have inlet ports 260 at first end 310 to receive exhaust flow 150 and porous end-plugs 270 at second end 320 to leak ash (depicted generally at 340). Exhaust flow 150 is in a direction parallel to the inlet and outlet channels 230, 250. The leakage of ash is typically more prevalent after regeneration where catalytic or thermal heating before or within particulate filter 200 burns the carbonaceous part of the exhaust particulates and assists in the separation of ash from soot.

[0016] In an embodiment, particulate filter 200 includes a known suitable heating means, such as electrical heater means or fuel burner means, not shown, to supply necessary heat to effect incineration of particles previously trapped by ceramic monolith structure 220 to effect regeneration thereof. Regeneration of ceramic monolith structure 220 serves to convert a substantial portion of the trapped exhaust particulates into ash particles for subsequent leakage through porous end-plugs 270.

[0017] Outlet channels 250 have outlet ports 280 at second end 320 to discharge exhaust flow 150 and end-plugs 290 at first end 310 to block the incoming exhaust flow 150. Exhaust flow 150 is filtered at the ceramic monolith structure 220 as it passes through the porous walls 240 between inlet and outlet channels 230, 250. Exhaust byproducts, such as metallic particles and carbonaceous matter, are trapped at porous walls 240, end-plugs 290, and porous end-plugs 270, whereas ash particles are passed, or more specifically leaked, through porous end-plugs 270. The filtered exhaust flow 150 is then discharged at outlet ports 280.

[0018] As discussed above, porous end-plugs 270 have a pore size equal to or greater than about 30 micrometers, and preferably have a pore size equal to or greater than about 30 micrometers and equal to or less than about 60 micrometers. Porous walls 240 and end-plugs 290, due to the pore size at those locations, do not permit

leakage of ash particles, thereby trapping some of the ash particles within particulate filter 200.

[0019] As disclosed, an embodiment of the invention provides for ash leakage from particulate filter 200 through porous end-plugs 270, thereby reducing or negating the need for mechanical cleaning of the ash particles from the particulate filter 200.

[0020] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.